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UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.	Total Pages in this Submission
55288(904)	48

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

IMAGE PROCESSING DEVICE

and invented by:

MITSURU TOKUYAMA, MASATSUGU NAKAMURA, MIHOKO TANIMURA, MASAAKI OHTSUKI, NORIHIDE YASUOKA

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 39 pages and including the following:
   - a. ☒ Descriptive Title of the Invention
   - b. ☐ Cross References to Related Applications *(if applicable)*
   - c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   - d. ☐ Reference to Microfiche Appendix *(if applicable)*
   - e. ☒ Background of the Invention
   - f. ☒ Brief Summary of the Invention
   - g. ☒ Brief Description of the Drawings *(if drawings filed)*
   - h. ☒ Detailed Description
   - i. ☒ Claim(s) as Classified Below
   - j. ☒ Abstract of the Disclosure

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   - a. ☒ Formal Number of Sheets 9
   - b. ☐ Informal Number of Sheets ____
4. ☒ Oath or Declaration
   - a. ☒ Newly executed *(original or copy)* ☐ Unexecuted
   - b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   - c. ☒ With Power of Attorney ☐ Without Power of Attorney
   - d. ☐ *DELETION OF INVENTOR(S)* Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference *(usable if Box 4b is checked)* The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Computer Program in Microfiche *(Appendix)*
7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   - a. ☐ Paper Copy
   - b. ☐ Computer Readable Copy *(identical to computer copy)*
   - c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers *(cover sheet & document(s))*
9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*
10. ☐ English Translation Document *(if applicable)*
11. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
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UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity) (Only for new nonprovisional applications under 37 CFR 1.53(b))	Docket No. 55288(904)
	Total Pages in this Submission 48

Accompanying Application Parts (Continued)

15. ☒ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
    Certified Copy of Japanese Patent Application No. 11-291947, Filed 10/14/99

16. ☐ Additional Enclosures *(please identify below)*:

Request That Application Not Be Published Pursuant To 35 U.S.C. 122(b)(2)

17. ☐ Pursuant to 35 U.S.C. 122(b)(2), Applicant hereby requests that this patent application not be published pursuant to 35 U.S.C. 122(b)(1). Applicant hereby certifies that the invention disclosed in this application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication of applications 18 months after filing of the application.

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An applicant who makes a request not to publish, but who subsequently files in a foreign country or under a multilateral international agreement specified in 35 U.S.C. 122(b)(2)(B)(i), must notify the Director of such filing not later than 45 days after the date of the filing of such foreign or international application. A failure of the applicant to provide such notice within the prescribed period shall result in the application being regarded as abandoned, unless it is shown to the satisfaction of the Director that the delay in submitting the notice was unintentional.

UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

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Docket No. 55288(904)

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Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra		Rate	Fee
Total Claims	20	- 20 =	0	x	$18.00	$0.00
Indep. Claims	1	- 3 =	0	x	$78.00	$0.00
Multiple Dependent Claims (check if applicable) ☐						$0.00
					BASIC FEE	$710.00
OTHER FEE *(specify purpose)*	Assignment Recordal					$40.00
					TOTAL FILING FEE	$750.00

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- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Signature

Dated: **October 6, 2000**

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CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10) Applicant(s): **Mitsuru Tokuyama, et al**			Docket No. **55288(904)**
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Invention:

IMAGE PROCESSING DEVICE

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is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 in an envelope addressed to: The Assistant Commissioner for Patents, Washington, D.C. 20231 on

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IMAGE PROCESSING DEVICE

FIELD OF THE INVENTION

The present invention relates to an image processing device which makes area determination (area separation) of a target pixel of inputted image data in a scanner, a digital copying machine, a fax machine and so on, and which performs image processing for each area.

BACKGROUND OF THE INVENTION

In a conventional image processing device, as disclosed in Japanese Unexamined Patent Publication no. 125857/1996 (Tokukaihei 8-125857, published on May 17, 1996), first and second characteristic parameters are found and inputted to a determination circuit using a nerve circuit network so as

to perform area determination (area separation) of a target pixel. Here, the nerve circuit network is a non-linear type and has been learned in advance. Besides, the non-linear type means that inputs of first and second characteristic parameters are respectively converted to coordinates on a vertical axis and a horizontal axis, and a separating state is shown on the coordinates.

When performing area separation using the above non-linear separating method, it is necessary to widely memorize coordinates. These coordinates are called a lookup table, which is adopted for converting an output based on an input axis. Therefore, such a lookup table uses a memory for storing data. Further, the conventional arrangement has required considerably large memory.

SUMMARY OF THE INVENTION

The objective of the present invention is to provide an image processing device capable of making fast area determination with high accuracy at low cost in a simple manner, without the necessity for memory with a large capacity.

In order to attain the above objective, the image processing device of the present invention is characterized in that upon area determination of a target pixel in inputted image data, total densities are computed for at

least four kinds of sub pixel groups provided in a main pixel group, which is constituted by a plurality of pixels including a target pixel, and area determination is made based on these total densities.

According to this arrangement, total densities of the four kinds of sub pixel groups are computed and area determination is made based on these total densities, so that memory with large capacity is not necessary for area determination. Further, the total densities are computed only by addition so as to provide an image processing device capable of fast area determination with high accuracy at low cost in a simple manner.

For a fuller understanding of the nature and advantages of the invention, reference should be made to the ensuing detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the construction of an image processing device according to one embodiment of the present invention and image processing steps thereof.

Fig. 2 is an explanatory drawing showing a main mask and a sub mask that are used in area separation of the image processing device.

Fig. 3 is an explanatory drawing showing a computing

method of a complication degree in a main scanning direction, the degree being used in area separation of the image processing device.

Fig. 4 is an explanatory drawing showing a computing method of a complication degree in a sub scanning direction, the degree being used in area separation of the image processing device.

Fig. 5 is a flowchart showing the steps of area separation of the image processing device.

Fig. 6 is a block diagram showing area separation performed by a parallel operation of the image processing device.

Fig. 7 is a truth table in which areas are set according to the determination results of the parallel operation.

Fig. 8 is an explanatory drawing showing a filter coefficient of a non-edge area that is used for a filter processing of the image processing device.

Fig. 9 is an explanatory drawing showing a filter coefficient of an edge area that is used for the filter processing of the image processing device.

Fig. 10 is an explanatory drawing showing a filter coefficient of a mesh dot area that is used for the filter processing of the image processing device.

Fig. 11 is a γ correction graph regarding a non-edge

area in a gamma changing operation of the image processing device.

Fig. 12 is a γ correction graph regarding an edge area in a gamma changing operation of the image processing device.

Fig. 13 is a γ correction graph regarding a mesh dot area in a gamma changing operation of the image processing device.

Fig. 14 is an explanatory drawing showing the relationship between a target pixel and an error diffusion mask that are used for an error diffusing operation of the image processing device.

DESCRIPTION OF THE EMBODIMENTS

Referring to Figs. 1 to 14, the following explanation describes one embodiment of the present invention.

As shown in Fig. 1, an image processing device of the present embodiment is constituted by an input density changing section 2, an area separating section 3, a filter processing section 4, a scaling section 5, a gamma correcting section 6, and an error diffusing section 7.

In an image processing of the image processing device, firstly, image data is inputted from a CCD (Charge Coupled Device) section 1 to the input density changing section 2. In the input density changing section 2, the inputted image

data is changed to density data, and the image data changed to density data is transmitted to the area separating section 3.

In the area separating section 3, as will be described later, regarding inputted image data, a variety of area separation parameters such as a total density and a complication degree of a sub mask, and an area of a target pixel in image data is determined based on a computing result. The determined area is transmitted as area data to the filter processing section 4, the gamma correcting section 6, and the error diffusing section 7.

Image data from the area separating section 3 is transmitted to the filter processing section 4 as it is. In the filter processing section 4, as will be described later, a filter processing is performed on each area of image data based on a predetermined filter coefficient. The image data which has been subjected to a filter processing is transmitted to the scaling section 5.

In the scaling section 5, a scaling operation is performed based on a predetermined scaling rate. The image data which has been subjected to a scaling operation is transmitted to the gamma correcting section 6. In the gamma correcting section 6, as will be described later, a gamma changing operation is performed on a gamma correcting table which has been prepared in advance for each area of the

image data. The image data which has been subjected to a gamma changing operation is transmitted to the error diffusing section 7.

In the error diffusing section 7, as will be described later, an error diffusing operation is performed based on an error diffusing parameter, which has been set in advance for each area of the image data. The image data processed in the error diffusing section 7 is transmitted to the external device 8. The external device 8 includes a memory, a printer, a PC, and so on.

The following discusses area separation processing performed by the area separating section 3. Fig. 2 shows the relationship between a main mask and a sub mask (also referred to as a "sub matrix") that are used for area separation. Here, main masks of a main pixel group are indicated by i0 to i27. Besides, a target pixel of the main mask is indicated by i10. Meanwhile, sub masks of a sub pixel group include four kinds of sub mask as follows.

Two sub masks are prepared as sub masks used in a main scanning direction. First sub masks in a main scanning direction are indicated by i0, i1, i2, i3, i4, i5, and i6. Second sub masks in a main scanning direction are indicated by i21, i22, i23, i24, i25, i26, and i27. The first and second sub masks in a main scanning direction make a pair.

Besides, two sub masks are prepared as sub masks used

in the sub scanning direction. First sub masks in the sub scanning direction are indicated by i0, i7, i14, and i21. Second sub masks in the sub scanning direction are indicated by i6, i13, i20, and i27. The first and second sub masks in the sub scanning direction make another pair.

The following Table 1 shows the names of the first and second sub masks in the main scanning direction and the first and second sub masks in the sub scanning direction.

[Table 1]

SUB MASK (SUB MATRIX)	NAME
i0, i1, i2, i3, i4, i5, i6,	mask-m1
i21, i22, i23, i24, i25, i26, i27,	mask-m2
i0, i7, i14, i21,	mask-s1
i6, i13, i20, i27	mask-s2

As mentioned above, in an area separation processing of the area separating section 3, the main masks and the sub masks are set and a total density is computed for each of the sub masks.

First, when a total density of the sub mask 'mask-m1' is represented by sum-m1, the total density is computed as follows.

sum-m1 = i0 + i1 + i2 + i3 + i4 + i5 + i6

In the same manner, when a total density of the sub mask 'mask-m2' is represented by sum-m2, the total density

is computed as follows.

sum-m2 = i21 + i22 + i23 + i24 + i25 + i26 + i27

Furthermore, a total density is computed in the same manner regarding the sub masks in a sub scanning direction. When a total density of the sub mask 'mask-s1' is represented by sum-s1, the total density is computed as follows.

sum-s1 = i0 + i7 + i14 + i21

In the same manner, when a total density of the sub mask 'mask-s2' is represented by sum-s2, the total density is computed as follows.

sum-s2 = i6 + i13 + i20 + i27

The four kinds of sub masks and two pairs of total densities are computed by the above equations. Subsequently, a sum S of total density differences of the pairs, i.e., a sum of a) a total density difference between two sub masks in a main scanning direction and b) a total density difference of two sub masks in a sub scanning direction is computed by the following equation.

$$S = |\text{sum-m1} - \text{sum-m2}| + (|\text{sum-s1} - \text{sum-s2}|) \times \alpha \quad \cdots (1)$$

Here, α of the equation (1) is a coefficient for normalizing a difference in size (number of pixels) between a sub mask in a main scanning direction and a sub mask in a

sub scanning direction. In this case, α is set at 7/4.

The sum S of total density differences is computed as above and is compared with a predetermined threshold value. When the sum S is larger than a threshold value, the area is determined as an edge area; otherwise, the are is determined as a non-edge area. The following Table 2 shows determination results of the area separation processing with a threshold value set at "150".

[Table 2]

TARGET TO BE DETERMINED	SUM S OF TOTAL DENSITY DIFFERENCES	DETERMINATION RESULTS
PICTURE CONTINUOUS TONE PART	5 to 30	ONLY NON-EDGE AREAS
10-POINT CHARACTER PART	140 to 320	MOSTLY EDGE AREAS OTHER THAN SOME NON-EDGE AREAS

As described above, it is possible to perform area separation between picture continuous tone part and a 10-point character part simply by computing the sum S of total density differences. Additionally, a range of a threshold value is not particularly limited.

Moreover, in the area separation, a size (number of pixels) in a sub scanning direction is relatively small so as to save line memory. Furthermore, in the area separation, the sub masks are disposed on the right, left, upper, and bottom ends of the main mask. A position of the

sub mask can be arbitrarily changed according to a size of the main mask, a detected image, and an input resolution.

Here, in the area separation, the sub mask differs in shape (size) between a main scanning direction and a sub scanning direction, so that a normalization coefficient is multiplied. However, a normalization coefficient does not need to be multiplied as long as the shape remains the same.

Regarding the area separation, the following describes an example using a complication degree.

Together with a sum S of total density differences regarding each pair of sub masks, a total of density differences is computed regarding pixels adjacent in a main scanning direction in the main mask and pixels adjacent in a sub scanning direction. Here, a total of density differences is referred to as a complication degree. However, in the area separation, a total of density differences is computed in a main scanning direction for every other pixel, not adjacent pixels. A complication degree also includes a total of density differences between pixels disposed with a predetermined interval.

Firstly, referring to Figs. 3 and 4, the following describes a method of computing a complication degree of the main mask. As shown in Fig. 3, when a complication degree is computed in a main scanning direction, a density difference is computed between a pixel on the top of the

arrow and a pixel on the rear end of the arrow, and density differences of all the arrows are summed. Thus, a total of density differences is computed on twenty places in total in a main scanning direction. Here, a density difference is an absolute value between a pixel on the top of an arrow and a pixel on the rear end of the arrow.

Regarding computing of a complication degree in a sub scanning direction, as shown in Fig. 4, a density difference is computed between a pixel on the top of an arrow and a pixel on the rear end of the arrow, and density differences of all the arrows are summed. Thus, a total of density differences is computed on twenty one places in total in a sub scanning direction. Here, a density difference is an absolute value between a pixel on the top of an arrow and a pixel on the rear end of the arrow.

As described above, in the area separation processing, density differences are summed for every other pixel so as to compute a complication degree in a main scanning direction. Meanwhile, density differences between adjacent pixels are summed so as to compute a complication degree in a sub scanning direction.

Here, a complication degree computed in a main scanning direction is represented by busy-m, and a complication degree computed in a sub scanning direction is represented by busy-s. In this case, a differential value 'busy-gap' of

these complication degrees is computed as follows.

busy-gap = |busy-m − busy-s|

And then, in contrast to a non-edge area detected by the sum S of total density differences, when the differential value busy-gap of the total complication values is larger than a predetermined threshold value ('120' in the following example), the area is determined as an edge area; otherwise, the area is determined as a non-edge area. Hence, a differential value busy-gap makes it possible to extract an edge area on a part which is hardly detected by the sum S of total density differences.

Subsequently, a total value busy-sum, which is a total of complication degrees in a main scanning direction and a sub scanning direction, is computed as follows.

busy-sum = busy-m + busy-s

In contrast to a non-edge area detected by the sum S of total density differences and a differential value busy-gap of complication degrees, when a total value busy-sum of complication degrees is larger than a predetermined threshold value ('180' in the following example), the area is determined as a mesh dot area; otherwise, the area is determined as a non-edge area. Table 3 shows each characteristic quantity of a mesh dot area and the determination results when area determination is made by the above area separation processing. Here, a range of each

threshold value is not particularly limited.

[Table 3]

	MESH DOT (BLACK AND WHITE 175 LINES, 30% DENSITY)	EACH THRESHOLD VALUE	DETERMINA-TION RESULT
SUM S OF DENSITY DIFFERENCES	50 to 80	150	NON-EDGE
busy-gap	40 to 90	120	NON-EDGE
busy-sum	230 to 340	180	MESH DOT

"Black and white 175 lines, 30% line density" of Table 3 indicates that a printed matter has a resolution of 175 lines and black and white ratio is 30 %. As shown above, the mesh area is determined as a non-edge area in determination made by a sum S of total density differences and a differential value busy-gap of complication degrees. However, based on a computing result of a characteristic quantity of a busy-sum, which is a total value of complication degrees, the area can be determined as a mesh dot area.

The following describes an example of the area separation using an average density or a total density of the main mask. A complete average density, a simplified average density, and a total density in the main mask of Fig. 2 are computed as follows.

complete average density = (total of i0 to i27)/28

simplified average density = (total of i0 to i27)/32

※ 32 is 2^5 (5-bit shift)

total density = (total of i0 to i27)

In the area separation, any one of the complete average density, the simplified average density, and the total density is applicable. These densities have the following characteristics.

With the complete average density, an average density of the main mask can be computed without an error; however, a coefficient of division is "28", so that the speed is not high as the simplified average density. Thus, another division circuit is necessary.

The simplified average density causes an error of "28/32" relative to the complete average density. However, when an image has a density of 8 bits and 256 levels of gradation, a density value may be increased to 13 bits to a maximum by computing a total density. In this case, the maximum value can be shifted by 5 bits. Thus, area determination is possible with a comparator having a maximum density of 8 bits.

The total density is the most simple. In the case of an image density of 8 bits and 256 levels of gradation, a comparator with a maximum density of 13 bits is necessary.

In the area separation processing, area determination using one of the complete average density, the simplified average density, and the total density is performed before

computing characteristic quantities such as the sum S of total density differences, a differential value busy-gap of a complication degree, and a total value busy-sum of a complication degree. Further, in the area determination using one of the complete average density, the simplified average density, and the total density, a computed density value is compared with a predetermined threshold value. When the density value is not less than the threshold value, an area is determined as a non-edge area. Additionally, the determined non-edge area remains the same in the area determination thereafter. This arrangement makes it possible to prevent an edge area from being detected on a high-density part.

If a high-density part is determined as an edge area, an error such as a contour may appear on a high-density part and a halftone area in a filter processing thereafter (described later). To prevent such a problem, as described above, area determination using one of the complete average density, the simplified average density, and the total density is performed so as to prevent the appearance of an edge area on a high-density part.

And then, referring to Fig. 5, the following discusses an operation example in which a threshold value of edge determination is changed in the area separation processing based on an edge determination result obtained by the above

sum S of total density differences.

In the area separation processing shown in Fig. 5, a simplified average density in the main mask is computed (step S1), and the density is compared with a threshold value ave (S2). When the simplified average density is at the threshold value ave or more, the area is determined as a picture area (non-edge area), and the determination result remains the same in area determination thereafter (S3).

When the simplified average density is smaller than the threshold value ave, a sum S of total density differences of the foregoing sub mask (sub matrix) is computed (S4), and the sum S is compared with a threshold value delta (delta = 150) (S5). When the sum S of total density differences is larger than the threshold value delta, the area is determined as a character area (edge area), and the determination result is remains the same in area determination thereafter (S6). Further, when the area is determined as a character area in S6, a feedback count is increased by "1". The feedback count is compared with a threshold value fb1 when the sum S of total density differences is at the threshold value 'delta' or less in S5 (S7). A threshold value fb1 is provided for determining a degree of the occurrence of a character area in a predetermined history. In the area separation processing, the predetermined history is a previous history of eight

pixels and a threshold value fb1 is set at "2".

Therefore, relative to a previous history of eight pixels, when an edge determination result regarding the sum S of total density differences has three pixels or more (namely, when a feedback count is larger than a threshold value fb1), the edge determination threshold value 'delta' is reduced by a predetermined amount fb2 (fb2 = 80). The reduced threshold value delta - fb2 is compared with the sum S of total density differences (S8). When the sum S of total density differences is larger than the threshold value delta-fb2, the area is determined as a character area, and the determination result remains the same in area determination thereafter (S9).

As described above, a threshold value of edge determination is changed based on an edge determination result of the previous history, and feedback correction is carried out so as to improve accuracy of edge determination based on the previous history.

When a feedback count is determined as a threshold value fb1 or less in S7, or when the sum S of total density differences is determined as a threshold value delta-fb2 or less, area separation processing is performed based on a complication degree.

A differential value busy-gap is computed between complication degrees in a main scanning direction and in a

sub scanning direction, and a total value busy-sum is computed between complication degrees in a main scanning direction and in a sub scanning direction (S10). And then, the differential value busy-gap of complication degrees is compared with a predetermined threshold value busy-g (busy-g = 120) (S11).

When the differential value busy-gap of complication degrees is not less than the threshold value busy-g, the area is determined as a character area (edge area), and the determination result remains the same in area determination thereafter (S12). When the differential value busy-gap of complication degrees is smaller than the threshold value busy-g, a total value busy-sum of complication degrees is compared with a predetermined threshold value busy-s (busy-s = 180) (S13). When the total value busy-sum of complication degrees is not less than the threshold value busy-s, the area is determined as a mesh dot area (S14). When the total value busy-sum of complication degrees is smaller than the threshold value busy-s, the area is determined as a picture area (S15).

When an area is determined in S3, S6, S9, S12, S14, or S15, the step returns to ① of Fig. 5, and the foregoing area separation processing is performed on the following pixel.

As earlier mentioned, the area separation processing is carried out in the order of: determination based on an

average density in the main mask, determination based on a sum S of total density differences of sub masks, determination based on feedback correction, determination based on a differential value busy-gap of complication degrees, and determination based on a total value busy-sum of complication degrees. In each determination, each of the above characteristic quantities (area separation parameters) is compared with each threshold value, and the area is determined. With this arrangement, the area separation processing does not require large memory, and three kinds of an edge area, a non-edge area, and a mesh area can be detected only by comparing characteristic quantities with threshold values.

Further, in a hardware arrangement, the operation based on the above characteristic quantities is not carried out in the above order but the characteristic quantities (an average density, a sum S of total density differences, a differential value busy-gap, a total value busy-sum) are computed and processed in parallel through a so-called pipeline operation so as to provide a simple hardware system with higher speed.

Fig. 6 is a block diagram showing the area separation processing using a parallel operation. The operations of blocks 21 to 23 correspond to steps S1 to S3. Moreover, the operations of blocks 24 to 27 correspond to steps S4 to S9,

and the operations of blocks 28 to 32 correspond to steps S10 to S15. In this case, the operations of the blocks 21 to 23, the operations of the blocks 24 to 27, and the operations of the blocks 28 to 32 are performed in parallel.

Besides, Fig. 7 is a truth table corresponding to Fig. 6, in which an area is set based on each result determined by the parallel operation. In Fig. 7, in a column "area setting", "0" indicates a picture area, "1" indicates a character area, and "2" indicates a mesh dot area. Further, in Fig. 7, columns "picture", "character 1", "character 2", and "mesh dot" respectively correspond to the block 23, the block 26, the block 30, and the block 32. When the blocks 22, 25, 29, and 31 the determination results of "yes", each of the columns turns "1". In the case of "no", each of the columns turns "0".

As described above, an area is determined as shown in the truth table of Fig. 7 based on each result of the parallel operation so as to provide a simple hardware system with a higher speed.

The following describes the filter processing which is performed in the filter processing section 4 of Fig. 1 based on a detection result of the area separation processing.

In the filter processing section 4, the filter processing is carried out using a filter coefficient previously set for each area. Fig. 8 shows a filter

coefficient of a non-edge area, Fig. 9 shows a filter coefficient of an edge area, and Fig. 10 shows a filter coefficient of a mesh dot area. Here, in the filter processing shown in Figs. 8 to 10, sums of products of image densities and values shown in lattices are respectively divided by 1, 31, and 55.

In this filter processing, a mask in a sub scanning direction is identical in size to a mask used in the area separation processing. Actually, in the case of a hardware construction, even when a mask size (particularly the number of lines in a sub scanning direction) is reduced in the area separation, the larger a filter processing mask is, the larger line memory is necessary.

Moreover, in the filter processing, an emphasizing level of the filter is the highest on an edge area and is the lowest on a non-edge area. Hence, based on detection results of the area separation processing, a filter coefficient is changed for each area so as to achieve an image processing with high picture quality.

Here, another coefficient is applicable as a filter coefficient for each area.

Next, the following describes the gamma changing operation performed in the gamma correcting section 6 based on the detection result of the area separation processing.

In the gamma correcting section 6, the gamma changing

operation is performed on each area by using a gamma correcting table which has been previously prepared. Fig. 11 shows a γ correction graph of a non-edge area. An input axis indicates post filter image data. In this example, an input has 8 bits and 256 levels of gradation, and an output also has 8 bits and 256 levels of gradation.

Fig. 12 shows a γ correction graph of an edge area. Input and output axes are the same as those of Fig. 11. Only when the area is determined as an edge area, an operation is carried out using a γ correction graph of Fig. 12. Furthermore, Fig. 13 shows a γ correction graph of a mesh dot area. Input and output axes thereof are the same as those of Fig. 11. Only when the area is determined as a mesh dot area, an operation is carried out using a γ correction graph of Fig. 13.

An actual hardware construction uses memory such as SRAM (static RAM) and ROM with an input of 8 bits and an output of 8 bits and 256 bytes, and after data is inputted to an address of SRAM and ROM on the input axis, image data subjected to γ changing is outputted from the output.

In comparison of γ correction graphs of Figs. 11 to 13, γ correction on an edge area makes the most rapid increase (namely, output data is large relative to input data). The gamma correcting table is set in this manner so as to clearly reproduce an edge area and an edge area with a low

density. In other words, different gamma correcting tables are respectively used for areas in a gamma changing operation based on the detection results of the area separation. Thus, image processing with higher picture quality is available.

The following describes an error diffusing operation performed in the error diffusing section 7 of Fig. 1.

In the error diffusing section 7, an error diffusion parameter is switched based on a result of the area separation processing, and an error diffusing operation is performed on each area by using a predetermined error diffusion parameter.

First, the following discusses an error diffusing operation. In this example, a binary error diffusing operation is carried out. The error diffusion is a kind of presentation of a dummy halftone and has been used as an image processing technique these days. Fig. 14 shows the relationship between a target pixel and an error diffusion mask. p represents a target pixel, and a to d represent pixels diffusing an error. First, when the target pixel p has a density of Dp, an error amount of Er, and a quantization threshold value (error diffusion parameter) of Th, the following relationship is established.

$$Dp < Th \rightarrow \text{quantized by } 0 \qquad Er = Dp$$

$$Dp \geq Th \rightarrow \text{quantized by } 255 \qquad Er = Dp - 255$$

An error amount Er computed as above is diffused on the pixels a to d of Fig. 14 by a certain coefficient. Namely, the pixels a to d respectively have coefficients Wa to Wd, and the total is set at 1. An error of Er × Wa is computed on the pixel a, an error of Er × Wb on the pixel b, an error of Er × Wc on the pixel c, and an error of Er × Wd on the pixel d. These errors are respectively added to the current density values of the pixels.

As described above, an error occurred in the target pixel is distributed to a predetermined pixel with a predetermined coefficient so as to quantize the target pixel. The quantized pixel is set at 0 or 255. Thus, assuming that 0 corresponds to 0, and 255 corresponds to 1, binary error diffusion is possible.

As shown in Table 4 below, in the image processing, a quantization threshold value Th serving as an error diffusion parameter is changed based on the result of the area separation processing.

[Table 4]

	Th
NON-EDGE AREA	128
EDGE AREA	100
MESH DOT AREA	128

As shown above, a quantization threshold value Th on an

edge area is set smaller than other areas so as to clearly reproduce an edge area. Namely, based on detection results of the area separation processing, error diffusion is performed using different error diffusion parameters respectively for the areas, so that image processing is possible with higher image processing.

Additionally, in the above example, a quantization threshold value Th is changed as an error diffusion parameter. However, a parameter to be changed is not particularly limited, so that other error diffusion parameters can be changed.

Besides, when area determination is made based on a total density of the four kinds of sub masks, the following area determination is possible in addition to the foregoing examples. Assuming that the four kinds of sub masks have total densities sum1, sum2, sum3, and sum4, a maximum value and a minimum value are computed for each of sum1 to sum4. The resultant values are respectively referred to as max and min. It is possible to make area determination based on a difference between max and min, i.e., a computing result of max - min. Namely, according to the area determination, when a computing result of max - min is larger than a predetermined threshold value, the area is determined as an edge area; otherwise, the area is determined as a non-edge area.

In the image processing device of the present invention, when making area determination on a target pixel of an image data to be inputted, a total density is computed regarding at least the four kinds of sub pixel groups, that are provided in a main pixel group constituted by a plurality of pixels including a target pixel, and area determination is made based on these total densities.

In the above area determination, it is preferable to determine if the target pixel is on an edge area or not. Hence, based on total densities of the four kinds of the sub pixel groups, an area can be divided into two kinds of areas, an edge area and a non-edge area. Here, an edge area is an area having a large difference in density. A character area is included in an edge area.

Further, when the sub pixel groups are different in size from one another, it is preferable to carry out normalization according to a coefficient. Therefore, even in the case of different sizes of sub pixel groups, area separation is possible with high accuracy. Moreover, this arrangement makes it possible to reduce the number of lines in a sub scanning direction. A size in a sub scanning direction affects the number of lines of line memory. Hence, the number of lines in a sub scanning direction is reduced so as to provide an inexpensive image processing device.

Also, it is preferable to dispose the sub pixel groups on or around the ends of the main pixel group. For example, the four kinds of sub pixel groups are respectively disposed on the upper, bottom, left, and right ends or around the ends of the main pixel group, so that information can be widely collected relative to a size of the main pixel group, thereby improving accuracy of area separation.

Further, it is preferable to categorize the total densities of the four kind sub pixel groups into two groups, to compute a value S by adding total density differences of the two groups, and to make area determination based on the value S. Hence, an adder for computing a total density, a subtracter for computing a difference in total density of the groups, and a comparator are used for area determination. Consequently, it is possible to provide an image processing device which can readily make fast area determination with high accuracy at low cost.

Also, it is preferable to compute a complication degree which is a total of density differences between adjacent pixels or pixels disposed with a fixed interval in a main scanning direction, and a complication degree which is a total of density differences between adjacent pixels or pixels disposed with a fixed interval in a sub scanning direction, and it is preferable to make area determination based on the computing results. This arrangement makes it

possible to further improve accuracy of area separation.

Additionally, after determination is made based on the value S if a target pixel is an edge area or not, it is preferable to compute a difference between a complication degree in a main scanning direction and a complication degree in a sub scanning direction regarding a non-edge area, and to determine again if the target pixel is an edge area or not based on the computing result. Thus, it is possible to detect an edge area which has not been detected using the value S.

Further, after determination is made if a target pixel is an edge area or not, it is preferable to compute a total of a complication degree in a main scanning direction and a complication degree in a sub scanning direction regarding a non-edge area, and to determine if the target pixel is a mesh dot area or a non-edge area based on the computing result. Hence, the area is divided into three areas of an edge area, a non-edge area, and a mesh dot area.

Furthermore, a complication degree in a main scanning direction is preferably a total of density differences of every other pixel, and a complication degree in a sub scanning direction is preferably a total of density differences of adjacent pixels. Hence, it is possible to compute a complication degree suitable for an input resolution and a size of the main pixel group (mask size).

Additionally, it is preferable to include the step of computing an average density or a total density in the main pixel group and determining if a target pixel is an edge area or not based on the computing results. Thus, it is possible to prevent a high-density part from being detected as an edge area. Particularly when a filter processing is performed on a high-density part of a halftone image, it is possible to prevent a problem such as a boundary on an image. Besides, determination is made based on a total density of the main pixel group so as to determine if a target pixel is an edge area or not without the necessity for a division circuit.

Also, when an average density in the main pixel group is computed, it is preferable to divide a total density by a power of 2, which is the closest to the number of pixels, not by the number of pixels. Hence, in a hardware construction, division is made by a bit shift, so that a value close to an average density can be computed without the necessity for a division circuit.

Besides, when determination is made if a target pixel is an edge area or not based on a total density of the sub pixel groups, after determination of an edge area is successively made for a predetermined times or with a predetermined frequency, it is preferable to change a threshold value for determining if a target pixel is an edge

area or not. Thus, it is possible to further improve accuracy of determining an edge area.

Further, upon area determination, it is preferable to perform a plurality of determination operations in a predetermined order. For example, the order of priority is used in area determination, and an area is determined based on the order so as to perform area separation only by determination using a threshold value, without the necessity for a complicated lookup table and circuit.

Furthermore, the following order is preferable: determination based on a computing result of an average density or a total density in the main pixel group, determination based on the value S, determination based on a difference between complication degrees in the main scanning direction and the sub scanning direction, and determination based on a total of complication degrees in the main scanning direction and the sub scanning direction. Hence, a desirable result can be achieved in the area separation.

Moreover, it is preferable to change a coefficient of filter processing based on an area determined in the area determination processing. This arrangement makes it possible to provide an image processing device with high picture quality.

Also, it is preferable to change a gamma correction

table based on an area determined in the area determination processing. This arrangement makes it possible to provide an image processing device with high picture quality.

Besides, it is preferable to change an error diffusion parameter based on an area determined by the area determination processing. This arrangement makes it possible to provide an image processing device with high picture quality.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An image processing device for computing a total density for at least four kinds of sub pixel groups provided in a main pixel group, which is constituted by a plurality of pixels including a target pixel, and for making area determination based on the total densities, upon area determination of the target pixel in an inputted image data.

2. The image processing device as defined in claim 1, wherein said area determination determines if said target pixel is an edge area or not.

3. The image processing device as defined in claim 1, wherein normalization is performed with a coefficient when said sub pixel groups are different in size from one another.

4. The image processing device as defined in claim 1, wherein said sub pixel groups are disposed on or around an end of said main pixel group.

5. The image processing device as defined in claim 1, wherein total densities of four kinds of said sub pixel groups are categorized into two groups, total density differences of said two groups are added so as to complete

a value S, and area determination is made based on the value S.

6. The image processing device as defined in claim 5, wherein in said main pixel group, a complication degree is computed by summing density differences between adjacent pixels or pixels disposed with a fixed interval in a main scanning direction, and a complication degree is computed by summing density differences between adjacent pixels or pixels disposed with a fixed interval in a sub scanning direction, and area determination is further made based on the computing result.

7. The image processing device as defined in claim 6, wherein after determination is made based on the value S if the target pixel is an edge area or not, a difference is computed between the complication degree in a main scanning direction and the complication degree in a sub scanning direction regarding a non-edge area, and determination is made again if the target pixel is an edge area or not based on the computing result.

8. The image processing device as defined in claim 6, wherein after determination is made based on the value S if the target pixel is an edge area or not, a total of the

complication degree in a main scanning direction and the complication degree in a sub scanning direction is computed regarding a non-edge area, and determination is made again if the target pixel is a dot mesh area or a non-edge area based on the computing result.

9. The image processing device as defined in claim 6, wherein the complication degree in a main scanning direction is a total of density differences of every other pixel, and the complication degree in a sub scanning direction is a total of density differences of adjacent pixels.

10. The image processing device as defined in claim 1, wherein an average density or a total density of said main pixel group is computed, and determination is made based on the computing result if the target area is an edge area or not.

11. The image processing device as defined in claim 10, wherein upon computing an average density of said main pixel group, a total density is not divided by the number of pixels but by a power of 2 being the closest to the number of pixels.

12. The image processing device as defined in claim 2,

wherein when determining if a target pixel is an edge area or not based on a total density of said sub pixel groups, after determination of an edge area is successively made for a predetermined times or with a predetermined frequency, a threshold value for determining if the target pixel is an edge area or not is changed.

13. The image processing device as defined in claim 1, wherein upon area determination, a plurality of determining operations are performed in a predetermined order.

14. The image processing device as defined in claim 13, wherein determination is made based on a computing result of an average density or a total density of said main pixel group, before determination based on the value S, determination based on a difference between the complication degrees in a main scanning direction and in a sub scanning direction, and determination based on a total of the complication degrees in a main scanning direction and in a sub scanning direction.

15. The image processing device as defined in claim 13, wherein determination is made in an order of: determination based on a computing result of an average density or a total density of said main pixel group, determination based on the

value S, determination based on a difference between the complication degrees in a main scanning direction and in a sub scanning direction, and determination based on a total of the complication degrees in a main scanning direction and in a sub scanning direction.

16. The image processing device as defined in claim 1, wherein all determination methods are executed in parallel: determination based on a computing result of an average density or a total density of said main pixel group, determination based on the value S, determination based on a difference between the complication degrees in a main scanning direction and in a sub scanning direction, and determination based on a total of the complication degrees in a main scanning direction and in a sub scanning direction.

17. The image processing device as defined in claim 16, wherein said area determination made in said parallel operation uses a truth table.

18. An image processing device for changing a coefficient of a filter processing based on an area determined in area determination processing of claim 1.

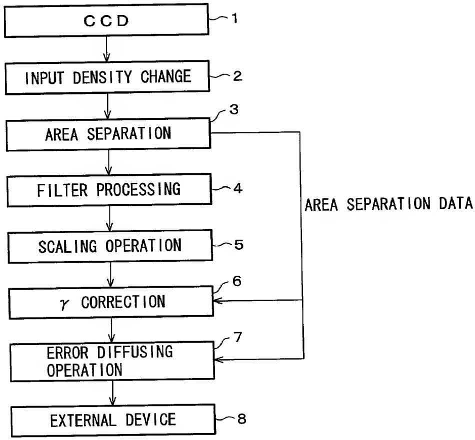
19. An image processing device for changing a gamma correction table based on an area determined in area determination processing of claim 1.

20. An image processing device for changing an error diffusion parameter based on an area determined in area determination processing of claim 1.

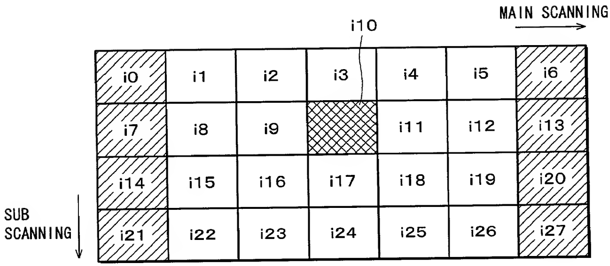
ABSTRACT OF THE DISCLOSURE

An image processing device of the present invention is provided with four kinds of sub masks in total including two kinds in a main scanning direction and two kinds in a sub scanning direction, in a main mask constituted by a plurality of pixels including a target pixel. In the image display device, when determining a target pixel of an inputted image data, a difference in a total density of the two kinds of sub masks in a main scanning direction is added to a normalized difference in total density of the two kinds of sub masks in a sub scanning direction, and a resultant value is compared with a threshold value so as to determine if the target pixel is an edge area or not.

FIG. 1

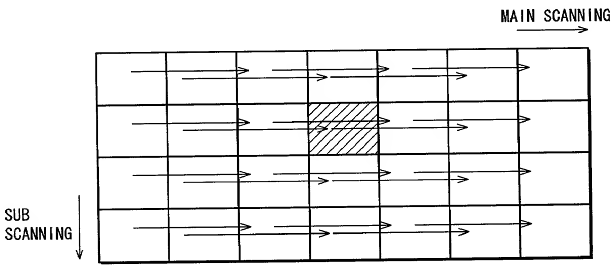

CCD
1
INPUT DENSITY CHANGE
2
AREA SEPARATION
3
FILTER PROCESSING
4
SCALING OPERATION
5
γ CORRECTION
6
ERROR DIFFUSING OPERATION
7
EXTERNAL DEVICE
8
AREA SEPARATION DATA

F I G. 2



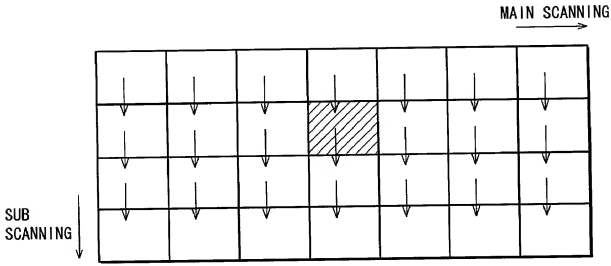
MAIN SCANNING
i10
i0
i1
i2
i3
i4
i5
i6
i7
i8
i9
i11
i12
i13
i14
i15
i16
i17
i18
i19
i20
i21
i22
i23
i24
i25
i26
i27
SUB SCANNING

F I G. 3

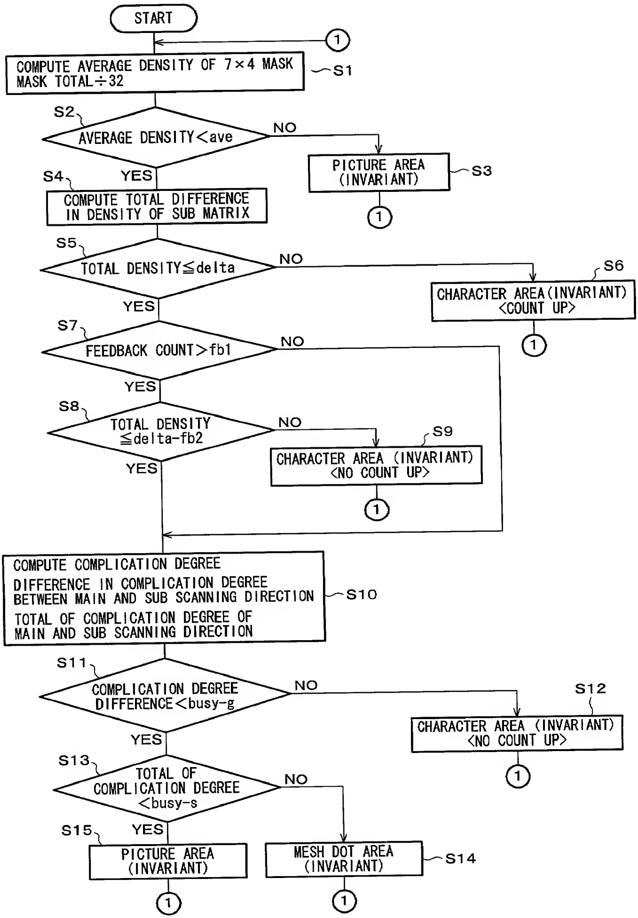


MAIN SCANNING
SUB SCANNING

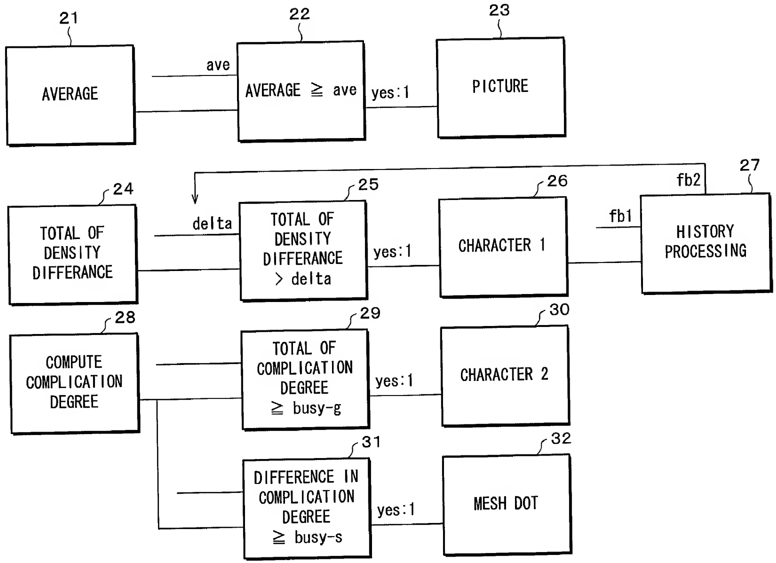
F I G. 4



F I G. 5


START
1
COMPUTE AVERAGE DENSITY OF 7×4 MASK
MASK TOTAL÷32
S1
S2
AVERAGE DENSITY<ave
NO
PICTURE AREA
(INVARIANT)
S3
1
YES
S4
COMPUTE TOTAL DIFFERENCE
IN DENSITY OF SUB MATRIX
S5
TOTAL DENSITY≦delta
NO
S6
CHARACTER AREA (INVARIANT)
<COUNT UP>
1
YES
S7
FEEDBACK COUNT>fb1
NO
YES
S8
TOTAL DENSITY
≦delta-fb2
NO
S9
CHARACTER AREA (INVARIANT)
<NO COUNT UP>
1
YES
COMPUTE COMPLICATION DEGREE
DIFFERENCE IN COMPLICATION DEGREE
BETWEEN MAIN AND SUB SCANNING DIRECTION
TOTAL OF COMPLICATION DEGREE OF
MAIN AND SUB SCANNING DIRECTION
S10
S11
COMPLICATION DEGREE
DIFFERENCE<busy-g
NO
S12
CHARACTER AREA (INVARIANT)
<NO COUNT UP>
1
YES
S13
TOTAL OF
COMPLICATION DEGREE
<busy-s
NO
S15
YES
PICTURE AREA
(INVARIANT)
1
MESH DOT AREA
(INVARIANT)
S14
1

F I G. 6



21
AVERAGE
ave
22
AVERAGE ≧ ave
yes:1
23
PICTURE
24
TOTAL OF DENSITY DIFFERANCE
delta
25
TOTAL OF DENSITY DIFFERANCE > delta
yes:1
26
CHARACTER 1
fb1
fb2
27
HISTORY PROCESSING
28
COMPUTE COMPLICATION DEGREE
29
TOTAL OF COMPLICATION DEGREE ≧ busy-g
yes:1
30
CHARACTER 2
31
DIFFERENCE IN COMPLICATION DEGREE ≧ busy-s
yes:1
32
MESH DOT

F I G. 7

PICTURE	CHARACTER 1	CHARACTER 2	MESH DOT	AREA SETTING
0	0	0	0	0
0	0	0	1	2
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

F I G. 8

0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0

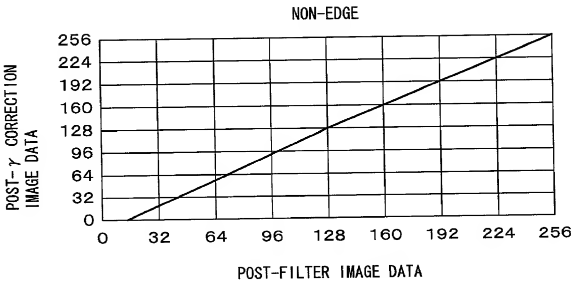
F I G. 9

−1	−1	−1	−1	−1
−1	−1	50	−1	−1
−1	−1	−1	−1	−1
−1	−1	−1	−1	−1

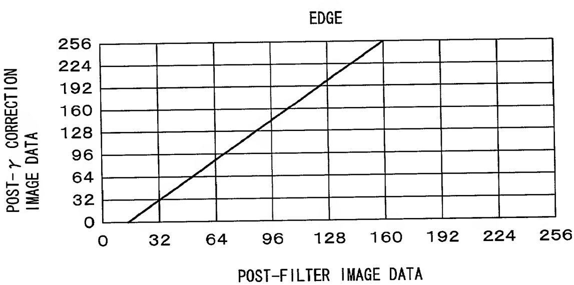
F I G. 10

−1	−1	5	−1	−1
1	3	50	3	1
−1	−1	3	−1	−1
−1	−1	1	−1	−1

F I G. 1 1


NON-EDGE
POST-γ CORRECTION IMAGE DATA
256
224
192
160
128
96
64
32
0
0
32
64
96
128
160
192
224
256
POST-FILTER IMAGE DATA

F I G. 1 2


EDGE
POST-γ CORRECTION IMAGE DATA
256
224
192
160
128
96
64
32
0
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32
64
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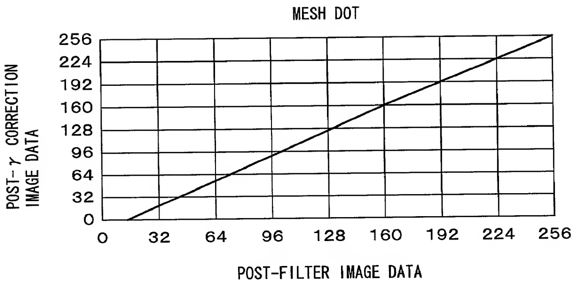
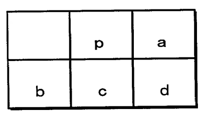
224
256
POST-FILTER IMAGE DATA

F I G. 1 3


MESH DOT
POST-γ CORRECTION IMAGE DATA
256
224
192
160
128
96
64
32
0
0
32
64
96
128
160
192
224
256
POST-FILTER IMAGE DATA

F I G. 1 4


p
a
b
c
d

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Boston, Massachusetts 02109

Attorney's Docket No. ________________

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that: My residence, post office address and citizenship are as stated below next to my name. I believe I am the original, first and sole inventor (if only one name is listed at 201) below or an original, first and joint inventor (if plural names are listed at 201-208 below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

IMAGE PROCESSING DEVICE

which is described and claimed in:

- ☒ the specification attached hereto.
- ☐ the specification in U.S. Application Serial Number ____________, filed on ______________.
- ☐ the specification in PCT international application Number ____________. filed on ____________; and was amended on ____________.

I hereby state that I have reviewed and understand the contents of the above identified specification. including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

Prior Foreign/PCT Applications and Any Priority Claims Under 35 U.S.C. 119:

Application No.	Filing Date	Country	Priority Claimed Under 35 U.S.C. 119?
11-291947	October 14, 1999	Japan	☒YES ☐NO
			☐YES ☐NO
			☐YES ☐NO
			☐YES ☐NO
			☐YES ☐NO
			☐YES ☐NO
			☐YES ☐NO

I hereby claim the benefit under 35 U.S.C. §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below, and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of 35 U.S.C. §112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

Prior U.S. Applications or PCT International Applications Designating the U.S-Benefit Under 35 U.S.C. §120					
U.S. Applications			Status (Check One)		
Application Serial No.		U.S. Filing Date	Patented	Pending	Abandoned
PCT Applications Designating the U.S.					
Application No.	Filing Date	U.S. Serial No. Assigned			

CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S) (35 U.S.C. § 119(e))

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

Applicant	Provisional Application Number	Filing Date

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) with full powers of association, substitution and revocation to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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207	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME
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I hereby further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signature of Inventor 201 Mitsuru Tokuyama	Signature of Inventor 202 Masatsugu Nakamura
Date: September 19, 2000	Date: September 19, 2000

Signature of Inventor 203 Mikoko Tanimura	Signature of Inventor 204 Masaaki Ohtsuki
Date: September 19, 2000	Date: September 19, 2000
Signature of Inventor 205 Yasuoka Norihide	Signature of Inventor 206
Date: September 19, 2000	Date:
Signature of Inventor 207	Signature of Inventor 208
Date:	Date: